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ABSTRACT

This paper reports on a qualitative study of children's discourse-reasoning about knowledge objects emerging when the classroom becomes a community of discourse. Its purpose was to analyze metacognitive reflections with respect to the steps of the argument. Within science education classes, a part of a wider ecological curriculum was implemented by engaging 22 fifth graders in a social constructivist learning environment in which discussions were the means of constructing shared knowledge. First the identified steps of the children's arguments and the different levels of their metacognitive reflections are presented. An analysis of how the latter were made explicit within the upward dynamics of argumentation follows. As hypothesized, the deepest steps of argument were characterized by the highest levels of metacognitive reflections. Examples show that when the children were searching for valid and critically sharable reasons on which to found and support their claims, they were induced to reflect on what, why, how, and when they knew. Therefore this study provides empirical evidence of the ways in which classroom discussions can stimulate higher levels of reasoning and arguing in children operating within their zones of proximal development in a kind of cognitive apprenticeship. (Contains 42 references and 6 tables). (Author/SLD)

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ED 371 041

ARGUMENTATION STRUCTURE AND METACOGNITION IN CONSTRUCTING SHARED KNOWLEDGE AT SCHOOL

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Abstract

This paper reports a qualitative study concerning children's discourse-reasoning about knowledge objects emerging when the classroom becomes a *community of discourse*. Its purpose was to analyze metacognitive reflections, considered as a kind of epistemic actions carried out by learners while arguing, with respect to the steps of argument. Within science education classes, a part of a wider ecological curriculum was implemented engaging twenty-two fifth graders in a social constructivist learning environment in which discussions were means of constructing shared knowledge. First, the identified steps of the children's arguments and the different levels of their metacognitive reflections are presented. Then, there follows the analysis of how the latter were explicited within the upward dynamics of argumentation. As hypothesized, the deepest steps of argument were characterized by the highest levels of metacognitive reflections. Examples show that when the children were searching for valid and critically sharable reasons on which to found and support their claims, they were induced to reflect on what, why, how, when they knew. Therefore, this study provides empirical evidence of the ways in which classroom discussions can stimulate higher level of reasoning and arguing in children operating within their zone of proximal development in a kind of cognitive apprenticeship.

> A discussion is useful to understand and reason. If we discuss together, all we can reason better ... yes, better, because it is not a single mind that thinks, there are many minds so we can reason and become convinced (*Chiara*, fifth grader).

Introduction

The research reported in this paper concerns an analysis of the classroom collective discourse emerging when the classroom, involved in knowledge construction and reconstruction, becomes a *community of discourse* (Brown et al., 1993). We assumed that schools should be communities where students *learn to learn* through various activities in different contexts. In this setting, teachers have the role of expert guides who act on the learners' zone of proximal development, continually on-line diagnosing their levels of understanding in order to lead them to more advanced levels of conceptual growth. Students are actively engaged in taking charge of their own learning with both individual responsibility and communal sharing (Brown, 1988; Brown et al., 1993). In particular, in a community of discourse students are constructive critics rather than passive containers of incoming information. In an innovative classroom atmosphere characterized by collaboration and cooperation, they take part in constructive discussions that are crucial moments of the learning process.

The aim of this study was to analyze children's small- and large-group discussions by relating the dynamics of argumentation to a particular kind of mental actions involved in classroom collective discourse about an object of knowledge: the metacognitive kind which is required as well as fostered by the social cognitive interaction.

The disciplinar domain in which discussions are examined is that of *environmental education* which is included in the current Italian curriculum for elementary school. As early as that, environmental education is extremely important to enable children, future citizens, to construct knowledge, skills, and attitudes to be effectively engaged in the best development of our societies (see Brody, 1990-91; Posch, 1993).

Theoretical framework

Social interaction in the classroom

The focus of the traditional research on learning is on individual activity, performed independently and silently, which leads to accumulate information, tune or restructure theories in

accordance with one's personal knowledge. A new developing research trend characterizes learning in general, and the development of specific understanding, as a social rather than and individual process. In the perspective developed by social constructivism, knowledge growth and change are the product of personal interactions in social contexts and of internalization of this socially constructed knowledge. The essentially social nature of individual cognition has therefore been emphasized (Resnick, Levine, & Teasley, 1991; Vygotsky, 1978; Wertsch, 1985). Researchers within the Piagetian tradition have also shown great interest in children learning in groups (Doise & Mugny, 1984; Perret Clermont, 1980).

For a long time research in educational psychology has pointed out the importance of social aspects in the classroom organizational structure, but until recently cooperative learning was mainly intended as a device to stimulate personal motivation and to develop socio-moral behavior (Slavin, 1983). The effects of cooperative learning in small groups, formed on the basis of different criteria, have been investigated at the levels of academic achievement, attitudes toward school activities, and ethnic relations (Sharan, 1980). Classroom learning based on individualistic, competitive, and cooperative didactic organizations has also been compared and contrasted (Johnson & Johnson, 1974, 1975). The new fruitful focus of the most recent studies on peer interactions in classrooms is on the *cognitive potential* of cooperative learning, that is, on the fostering of higher level thinking processes. Collaborative situations such as discussions, both between peers and between teachers and students, have been studied to examine their knowledge building function during the implementation of curricular units of physics, economics and history (Pontecorvo, 1987; 1990). The basic assumption, within a Vygotskian frame of reference, is that reasoning in children is mainly manifested in the externalized form of discussing and arguing with others. Analyses of discussions recorded in elementary classes have pointed out the conceptual complexity and the higher level of reasoning that occur in social cognitive classroom interactions. Peer group discussion about an object of knowledge can not only develop co-elaboration and co-construction but also opposition and argument: a learner can be required to explain, elaborate, or defend one's own point of view to others, as well as to oneself (Santi, 1992). In order to construct an explanation, a learner often integrates and elaborates knowledge at a more advanced level (Brown & Campione, 1990). Further, the group plays an important role for the children's actualization of knowledge by sharing mental effort, supporting the emotional level, and reducing anxiety (Pontecorvo, 1987). The introduction to group discussion techniques is the core of the well known reciprocal teaching which has been applied to the understanding and remembering of text content (Brown et al., 1993; Brown & Palincsar, 1989; Palincsar & Brown, 1984) to create a zone of proximal development in which novices can take on greater responsibility for more expert roles. In a cooperative context, while the group provides social support, shared expertise, and role models, the teacher provides expert scaffolding, gradually faded in, in modulating the children's discussion during the practice of four strategic activities. Conceptual change is also supposed to be stimulated and supported in learning contexts that produce dissatisfaction with the existing state of knowledge. A

school environment which encourages questioning, criticizing, and evaluating is believed to be a fruitful breeding ground for restructuring (Brown & Palincsar, 1989; Peasley, Rosaen, & Roth, 1993; Pontecorvo, 1990). In sum, it can be stated that social cognitive interaction in the classroom gives learners cognitive apprenticeship opportunities to acquire cultural reasoning and argumentation ways (Collins, Brown, & Newman, 1989).

Argumentation and reasoning

In accordance with Toulmin, Rieke, and Janik (1979), we think that reasoning space is a public, interpersonal and social space and therefore it is dialogic. In other words, we cannot isolate argumentative reasoning from the empirical fact of communication since argumentations are social processes central to the creation, maintenance and use of knowledge (Willard, 1989). We can see argumentation as a set of arguments expliciting opposition between two incompatible positions, or as a technique which guarantees rational and prudent decisions. What we mean here by argumentation is rather a form of communication in which the *epistemic* interest is the social constitution of knowledge; the *analytical* interest concerns the structure, coherence, and contexts of reasoning; the *critical* interest concerns the validity conditions and possibilities of a shared discourse (Willard, 1989). Thus, reasoning is not a way of arriving at ideas, but a way of testing ideas critically (Toulmin, Rieke, & Janik, 1979). In that sort of "critical transaction" the participants value the set of reasons offered as support of the different positions by means of shared standards, which are dependent on the domain.

The argumentative dimension of the thinking process is fundamental in all the different fields of knowledge, in informal reasoning (Voss, Perkins, & Segal, 1991) as well as in scientific reasoning (Kuhn, 1993 a, b). Argumentation skills work in children as well as in adults (Volzing, 1981). When we look for reasons, advance justifications, try to explain something, oppose rebuttals, suppose solutions, evaluate evidence, consider alternative positions, argumentation attitudes and skills are involved. We use and develop what the traditional literature calls *critical* and *rational* thinking, the main aim of cognitive education. Toulmin (1958) and Toulmin, Rieke and Janik (1979) identified the constituent parts of an argument, understood as a train of reasoning to support a position. The constituents, applied to our study to analyze the children discussions, are: *claims*, that is, assertions put forward for general acceptance; *grounds*, that is, the specific facts relied on to support a given claim; *warrants*, that is, statements indicating the general ways of arguing, used in discussing the justification and trustworthiness of the steps from grounds to claims; *backing*, that is, generalizations expliciting the body of experience and knowledge relied on to establish the trustworthiness of the ways of arguing in that particular case. Moreover, there are another two constituents whose role is crucial in an argument: *modal qualifiers* which regard the strength and condition of validity of a proposed argument, that is the degree of reliance to be placed on the conclusion, and *rebuttals* which are the extraordinary or

exceptional circumstances that might undermine the force of the supporting arguments. It is remarkable that the various elements are not in sequence but interdependent, so that we cannot be satisfied with the reasoning validity without considering all the steps of argument, and we cannot be satisfied with one of the elements without knowing something about all the others. The argumentation activity can be seen as very close to what is called "reflective thinking" and involves, from the psychological point of view, the use and strengthening of metacognition.

Metacognition

The term metacognition "is an umbrella term representing many interacting processes and skills that facilitate self-awareness of one's own cognitive processes and capabilities" (Carr & Borkowski, 1989, p. 327). It is often used in such variable ways that its explanatory value may be lost (Kuhn, Amsel, & O'Loughlin, 1988). The following are some of the different ways in which it has been used. Flavell (1976) explicited the multidimensional character of metacognition that concerns awareness of one's own thinking, active monitoring of one's cognitive processes, and the consequent regulation of these processes in relation to the cognitive objects or data on which they bear. Recently, White (1993), on the basis of his experience with the Project for Enhancing Effective Learning (PEEL) focused on the promotion of metacognition in students, has added a fourth aspect to the three identified by Flavell: willingness to exercise the control of one's own thought processes. Metacognition has been defined as "knowing about knowing" by Brown (1978) who divided metacognitive activities in two categories to differentiate what people know about their cognitive processes from the application of strategies as heuristics in learning or problem solving situations. The first category includes activities related to conscious reflections on one's cognitive abilities, the second category concerns activities related to self-regulated mechanisms while people are learning or solving problems. According to Kuhn, Amsel, and O'Loughlin (1988), the essential aspect of metacognition is the ability to think explicitly *about* a theory one holds rather than merely thinking *with* that theory. A person is metacognitively competent when able to represent her or his conceptions as objects of cognition; therefore metaconceptual reflections are considered as reflections on conceptions rather than unreflected applications of them to the explanations of phenomena. More recently, Hennessey and Beeth (1993; Hennessey, 1993), who have been implementing in elementary school Project META (Metacognitive Enhancing Teaching Activities), based on the use of the term metacognition given by Kuhn, Amsel, and O'Loughlin (1988), have illustrated the different levels of metacognitive reflections explicited by students while learning science concepts. They range from a minimal level of awareness of one's own or peers' conceptions to levels of more sophisticated abilities such as reflections referring to one's own thinking or learning processes and to the components of one's own conceptual ecology.

Students' metaconceptual awareness has recently been acknowledged as an important factor in

conceptual change. Researchers who have investigated conceptual development in scientific domains (for example, Hennessey, 1993; Mason, in press; Roth, 1990; Vosniadou, 1991 a, b; Peasley, Rosaen, & Roth, 1993) have clearly pointed out that learners need to be aware of the conceptions through which they interpret events and continuously and deliberately monitor their own developing understanding while trying to use new information to explain and make predictions. Therefore, fostering students' metacognition as ability of thinking explicitly *about* the ideas or conceptions they hold has an impact on their conceptual growth and change.

In the study reported below the term metacognition is understood in the meaning given to it by Kuhn, Amsel and O'Loughlin (1988), used by Hennessey and Beeth (1993; Hennessey, 1993) and so, it refers to the inner awareness or ability to reflect on what, why, how, when one knows. We refer neither to the execution of a sequence of strategies to successfully accomplish a task nor to the self-regulation of one's behavior while performing tasks.

Discussion, argumentation and metacognition

The context of a collective discourse in a classroom discussion aiming at problem understanding or solving is a context in which the metaconceptual dimension of awareness is activated in students, since a dialogic and collaborative learning situation makes the explicitation of metacognitive reflections necessary. For a discussion to be productive for learning, the interlocutors need to continuously consider their own viewpoints (beliefs and conceptions) in relation to the others' viewpoints to participate not only in terms of contraposition and conflict but also of co-construction and sharing knowledge. In the latter case, in fact, a higher level of metacognitive awareness is entailed as the participants have not only to negotiate meanings but also to mediate different positions to collectively build new ones. A classroom collaborative setting should be aimed at shared and rationally sharable knowledge constructing. Terms, definitions, ideas, beliefs, etc. are negotiated and renegotiated through questioning and criticism as well as confirmation and assent. As Brown and collaborators (1993) have pointed out, referring respectively to Wertsch and Edwards and Mercer, a kind of "a common voice" or "a common knowledge base" is formed over time.

The construction of shared knowledge is facilitated in an interaction context since a higher cognitive effort is distributed among the participants. On the other side, the metacognitive competence required to develop an argumentative reasoning is modeled, by exercising the alternation of argumentative turns gradually internalized, in a kind of cognitive apprenticeship.

A growing research field concerns the analysis of discussions aimed at the construction of disciplinar knowledge. On one side, this analysis focuses on the steps of argument and argumentation processes (Eichinger, 1993) and, on the other, on the epistemic actions corresponding to the different cognitive procedures involved in the argumentative interactions while understanding curricular concepts

(Pontecorvo, 1987, 1990). Among the more sophisticated epistemic actions there is the metacognitive one which corresponds to the explicitation of reflections on one's own knowledge and beliefs. It is this kind of reflection which allows to be aware of limitations, contradictions, fallacies, exceptions, implications, and presuppositions of one's own conceptions. One of the aspects that still needs to be investigated is the relationship between argumentation dynamics and different levels of metacognitive awareness explicited by the interlocutors during a discussion. Identification of the steps in which metacognitive thinking is more stimulated within a context of a collective argument aimed at shared knowledge construction would be crucial for the design of school learning environments fostering that dimension of thinking.

The qualitative study reported below investigates reflective thinking in elementary school children argumentation processes, engaged in small- and large-group classroom discussions on ecological topics. Its goal was to examine lower and higher levels of metacognitive reflections, considered as epistemic actions carried out by learners in their processes of knowledge building, with respect to the steps of argument. To this aim, in children's collective discourse-reasoning we examined:

1. the constituent elements of argument;
2. the different epistemic actions in the various steps of argument;
3. the different levels of metacognitive reflections;
4. the levels of metacognitive reflections within the upward dynamics of argumentation.

We expected the deepest steps of arguments to be characterized by the highest levels of metacognitive thinking. The analysis that a discussion participant, when provoked, makes of her or his position to explicit and clarify its backing requires sophisticated metacognitive actions expressed in statements defending her or his claim. An argument could lead to confirm or disconfirm the controversial claim. In the former case the collective discourse constructs a shared reasoned view; in the latter the participants can experience the need for conceptual change by restructuring their conceptual ecology.

Method

Subjects. The subjects were twenty-two fifth graders, aged between 10 and 11 years, attending two classes in a public elementary school in a rural area of Padova (Northern Italy). They shared a homogeneous middle class social background. Approximately half were girls and half boys.

Material. Within science education classes, a part of a wider ecological curriculum was implemented to focus on some crucial concepts such as air, water and soil pollution (causes, consequences, corrections), solid waste and recycling. It is noteworthy that these concepts were dealt with in both classes but in different ways. Some aspects of the phenomena were emphasized in one

class and some others in the other class, on the basis of the problems expressed by the children while discussing.

Setting. An innovative teaching-learning context was created to implement this curriculum by adopting a methodology which stimulated social cognitive peer interaction: large-group discussions (the whole class) and small-group discussions (4/5 children at heterogeneous levels of abilities). Such a constructivist learning environment, rather than simply presenting information in texts or lectures, encouraged questioning, criticizing and evaluating. We assumed that it was a fruitful breeding ground for the acquisition or refinement of metacognitive competence, in particular metaconceptual awareness, which, in turn, could stimulate knowledge restructuring.

We have to point out that classroom discussions were aimed at different goals in the various learning contexts. More specifically, the functions of the collective discourse-reasoning were: a. to explicit and compare prior knowledge on the considered topic to create a common ground; b. to recognize a common problem space; c. to formulate and compare hypotheses about phenomena or situations; d. to examine empirical data on the basis of predictions; e. to revise a theory in the light of evidence; f. to propose alternative solutions to a given problem.

The teachers involved in the implementation of this ecological curriculum were already trained in creating interactive learning environments through discussions. The researcher fitted in with this school setting in each session devoted to that part of the curriculum (about one hour twice a week for four months). The curriculum was spread over the whole school year.

Data collection procedures. Data were collected by audiorecording each discussion. Whole-class and small-group discussions were transcribed as were the initial and final individual interviews. The initial interview was aimed at collecting data on the children's prior knowledge on the new topics to be learned. The final interview was aimed at collecting data on what they had understood about the topic and on the metaconceptual awareness of changing their mind through the instructional intervention. The children's written production on the topics was also taken into account.

Data analysis procedure. The analysis of the structure of classroom discussions is based on the framework proposed by Toulmin (1958) and Toulmin, Rieke, and Janik (1979). Taking into account this interpretative framework, it also seemed relevant to analyze the discussions through some *epistemic* categories which highlighted the corresponding cognitive actions carried out by the children (Pontecorvo, 1987; 1990). Only the metacognitive one was stressed in order to identify different levels of metaconceptual reflections. In this way it was possible to study the relationship between steps of argument and the children's reflective thoughts. We examined the most significant trains of reasoning by considering each dialogic exchange from the point of view of the argument development and of the metacognitive actions involved.

Results

Prior Knowledge

It was not within the aim of this study to compare and evaluate the knowledge held by each student at the beginning and at the end of the curriculum implementation. However, we investigated and took into account what they already knew on the topics to be learned in order to design and realize a more appropriate instructional intervention.

Through the initial interview and the first discussions, we were able to know what ideas had been developed by the children on pollution, waste and recycling. Here, most of the data regard the first topic which had not been dealt with in the classroom but had been and still was much publicized by the mass media.

Summarizing prior knowledge to give an outline of the children's initial knowledge scenario, we can say that the majority of them held a partial, little articulated concept of pollution: "Pollution is the dirt"; "Pollution is smog in the air"; "Pollution are bottles in the rivers and in the sea"; "Pollution are pieces of paper on the ground". A first distinction between air, water and soil pollution could be seen, but the recognition of the corresponding polluters was limited and often inappropriate. Just one child, for example, referred to the soil pollution due to the use of chemical fertilizers and pesticides in agriculture. Several children stated that chemically treated fruit and vegetables were better and healthier than those grown naturally since they were not "ill because of the worm inside". These are relevant data if we consider that the children lived in a rural area and knew that farmers had to wear masks to spray several produce with chemicals, and that the produce could not be picked before a set period of time had elapsed. Several children expressed their solutions to pollution problems. These showed a simple view of very complex problems. For example, they proposed: "To stop throwing pieces of paper on the ground"; "To close the factories"; "To build no more roads"; "To stop using cars"; "To stop producing cars". A fanciful solution was proposed by Paolo who wrote: "In my opinion, waste could be sent in space but we need a lot of money for spaceships and then they cannot pull twenty or thirty trucks full of waste".

More voices for one reasoning

First of all, the social nature of discourse-reasoning should be pointed out. The following passage[1] is an example of how a thought, passing from mind to mind, becomes a reasoned view built

[1]The numbers in parentheses refer to the statements uttered in the class in the same order as they were made. The children's sentences were translated trying to keep the same "style" as in the original Italian version. Grammar and style

by the discussion interlocutors who confirm and add a piece of reasoning to those already explicited in order to support a position of the "community of minds". The children were deeply engaged in convincing the only classmate who believed that manure was harmful to the soil, like poison, that it was not the case.

Table 1. Is manure a fertilizer?

(329) *Federico*: May I ask a question? If you see that a field is manured by farmers and another field isn't, then wheat is sown in both fields at the same time, in which field do you think it'll grow better?
(330) *Jessica*: The field without manure.
(331) *Michela*: But manure ..
(332) *Sheila*: Manure helps a plant.
(333) *Giordano*: It gives more life to the crop.
(334) *Paolo*: It makes things grow better.
(335) *Teacher*: What do you think about what they've said?
(336) *Michela*: Manure helps the soil to produce fruit.
(337) *Federico*: It's a natural fertilizer.
(338) *Giordano*: Yeah, good job!
(339) *Paolo*: It's stored for the soil.
(340) *Michela*: If farmers sow something without manure, plants can grow ...
(341) *Giordano*: Crooked.
(342) *Federico*: Crookedness doesn't matter, they can grow badly, remain ...
(343) *Paolo*: Very small.
(344) *Federico*: For example, corn can produce fewer cobs.
(345) *Michela*: Birds get to the cobs.
(346) *Teacher*: That doesn't get into it.
(347) *Giordano*: Yes, right! Birds have got nothing to do with that.
(348) *Paolo*: If a farmer spends a lot of money to rent the machine to manure fields, this means that he believes manure's useful, doesn't it?
(349 *Jessica*: He believes that, not me!

In the above example the community of minds shared a single position against one classmate. More typically, in a community of minds different positions are developed, compared, challenged, and negotiated in order to reach common critical knowledge. Let us see the argumentative structure of the classroom discussions.

Constituent elements of argument

We analyzed all the whole-class and small-group discussions and then chose the more relevant ones from the point of view of the dynamics of argumentation. The first level of analysis was the identification of the elements which constitute arguments according to Toulmin (1958) and Toulmin, Rieke, and Janik (1979). In the following excerpt we can see the different elements of argument corresponding to the various steps of interaction originated while discussing about the effects of

errors were not corrected unless prejudicial to understanding.

experiments on biodegradability of some materials. The children were discussing the result of an experiment: a piece of cardboard left for one month in a bottle full of soil had partially gone mouldy.

Table 2. What happened to the cardboard?

	Steps of Argument
(70) *Sandro*: I was thinking whether soil could grow m o ldy ... the soil grows m o ldy, the cardboard's inside the soil and then the soil sticks to it so the m o ld's passed on to the cardboard.	*Claim*
(71) *Teacher*: You mean that the soil's stuck to the cardboard, not the cardboard's grown m o ldy.	
(72) *Matteo*: I think the cardboard's grown m o ldy, not the soil.	*Claim*
(73) *Teacher*: Matteo, could you show that you're right? How could you explain that what Sandro's said isn't true?	
(74) *Matteo*: I can easily show it [he cleans the soil from the cardboard]. The m o ld's on the cardboard not on the soil.	*Ground*
(77) *Andrea*: I'd tell him that later, when you empty the bottle with plastic in it, and we'll see that the soil hasn't grown m o ldy.	*Rebuttal*
(78) *Giovanni*: My brother, that's Sandro, has said that the soil grows m o ldy, therefore when it rains on our vegetable gardens we should see the soil all m o ldy.	*Rebuttal*
(81) *Teacher*: Do you think that a nail left in the soil can grow m o ldy?	
(82) *Many*: No! No!	
(84) *Giovanni*: If the nail gets wet by some water drops it can rust. It doesn't grow m o ldy but it changes all the same, it rusts and it might break over time.	*Ground*
(85) *Teacher*: Why does the cardboard, and not the nail, grow m o ldy? What's your idea?	
(92) *Laura*: I, too, wondered, because cardboard shouldn't grow m o ldy.	
(93) *Giovanni*: Perhaps it could, because in the soil there's always moisture and then it couldn't breathe, so to speak. If we'd put the nail in the soil it would have rusted. Iron rusts because of water.	*Grounds and Warrant*
(100) *Teacher*: But why does it rust while other materials get m o ldy?	
(101) *Sara*: There are some materials less resistant than others to the m o ld. I need to think about this for a while.	*Ground*
(105) *Giovanni*: I think it's something coming from trees that's then worked in a factory. It's something man-made. I didn't think that an artificial thing made in a factory could grow m o ldy.	*Backing*
(106) *Laura*: Cardboard is weaker than vegetables; at least, vegetables are more used to staying in the soil.	*Warrant*

In this passage of whole-class discussion the children tried to interpret an unexpected result as they had made the prevision that the cardboard in the soil would not undergo any change, but would only get dirty. Actually, they found the cardboard moistened with spots of mould. Sandro's effort to attribute the mould to the soil rather than to the cardboard soon failed challenged by the classmates' arguments developed in terms of grounds, rebuttals, warrants, and backing.

Epistemic actions

To characterize a discussion at the level of participants' cognitive involvement about an object of knowledge, it is possible to recognize in a collective discourse-reasoning the different epistemic actions carried out by the interlocutors. They are different cognitive linguistic operations corresponding to cognitive procedures, more or less productive to the understanding of situations, events, phenomena: explicitation of linguistic statements as definitions or denominations; reference to data, facts, proofs; reference to personal experience; recognition of significant variables; establishing causal or temporal relations, analogies, and models; reference to general principles, laws, empirical generalizations; recognition of a reference context; explicitation of metacognitive reflections (Pontecorvo, 1987; 1990). These epistemic actions can be carried out in different fields of knowledge and some more specific others can characterize a particular domain.

Here, a transcription excerpt from a whole-class discussion shows some of these epistemic actions which led the children, who held different conceptions, to the sharing of a piece of knowledge. Engaged in understanding where well-water came from, they discussed about sea water in order to find out whether well-water was salted and whether it came from the sea.

Table 3. Salt in water

	Epistemic Actions
(210) *Teacher*: Does salt dissolve in sea water or doesn't it?	
(211) *Some*: Yes, yes, it does.	
(212) *Barbara*: Yes, because water dissolves salt.	*Establishing relations*
(213) *Jessica*: The fact is that we don't see any grains of salt.	*Reference to data*
(214) *Federico*: But we don't see them because there's too much water and too few grains.	*Identification of variables*
(215) *Jessica*: If Federico performs the experiment as Michela's said	
(216) *Federico*: No, no, now I remember! Salt's also found in mines; miners dig holes under the sea water and they find salt.	*Reference to data*
(217) *Jessica*: If you put water and salt in a pan, after a while the salt ... when you go to drink the water, you don't see the salt any more.	*Reference to data*
(218) *Federico*: But if you remove the water, you can see the grains of salt.	*Identification of variables*
(228) *Federico*: You don't see the grains of salt but they're there on the bottom!	*Reference to data*

(229) *Barbara*: May I ask a question? If you put salt in a pan to cook pasta, does it dissolve?	*Establishing relations*
(230) *Federico*: I don't know. (231) *Teacher*: Do you find grains of salt in your plate? (232) *Federico*: Salt always remains whole.	*Reference to (alternative) general principles*
(233) *Barbara*: No, no, it dissolves!!	*Reference to general principles*
(234) *Federico*: Maybe it dissolves in warm water.	*Identification of variables*
(235) *Sheila*: In last year's textbook there was a glass of water with sand in it and one with salt. It was illustrated that the salt dissolved while the sand didn't.	*Reference to data*
(238) *Jessica*: Oh yes! I tried: I put salt in one glass of water and sand in another. The sand became wet and the salt dissolved.	*Reference to personal experiences*
(239) *Teacher*: How can you be sure that the salt dissolves? (240) *Jessica*: I know that if I drank that water, I would taste the salt, just the salt not the grains of salt.	*Consideration of metacognitive nature*
(241) *Teacher*: Is it convincing? (242) *Federico*: Yes, it's almost convincing me.	*Consideration of metacognitive nature*

All the children said that well-water came from the sea. However, Federico pointed out that well-water was not salted. In trying to reconcile the idea of where it came from with the idea of its taste, he expressed an alternative conception on the dissolution of salt in water by stating that salt does not dissolve completely so it can be filtered by the soil before reaching the wells. In such a way, Federico formulated an ad hoc hypothesis to defend his conception from the classmates' challenges, assigning importance in turns to different variables of the situation. The other disputers, by retrieving data coming from their previous personal or school experience, connecting familiar facts, referring to general principles, made Federico understand the groundlessness of his conception. By reflecting on what his classmates said, Federico clearly admitted that they had almost convinced him.

Levels of metacognitive reflections

As concerns the metacognitive action, different kinds of metaconceptual discourse produced by the children while discussing were identified. They represent four levels of reflection which allow to think "about" a conception rather than "with" a conception and to think about thinking as a process.

As we can see below, they emerged in the various steps of argument. Here, some examples of the identified levels are presented out of the dialogic sequence.

1. Awareness of what one knows

The first level of metacognitive reflection represents the necessary condition to be able to think about a conception. When discussing, a child is required to be aware of her or his own knowledge and beliefs to compare them with others' knowledge and beliefs and confirm or disconfirm them or even "to suspend judgment". This first kind of awareness does not entail the explicitation of a reasoning.

Sara: Pesticides produce other effects on fruit, vegetables and plants. They may be dangerous to the environment and also to the vegetables themselves. This is my idea. I'm against the use of pesticides and I look for more natural things.

2. Awareness of why one knows something

The second level concerns metacognitive reflections on the reasons that lead to a conception. They can be empirical evidence, schemata, and models through which the children express the reasoning underlying their knowledge.

Sheila: I think that there are pipes which carry water to a well because I know that the soil cannot transport water, water needs a kind of pipe to flow through.

Sara: I say that a steak in a freezer bag becomes hard because I know that it's cold inside a freezer, but I say that a steak without a bag becomes hard the same. The steak without the bag can absorb some water since ice is water in the solid state, and therefore it becomes as hard as a steak in the bag, but the steak in the freezer bag tastes better.

3. Awareness of knowledge construction procedures

The third level is a kind of awareness which points out the epistemological value of a conception in terms of its degree of certainty, consistency, plausibility, generalizability, explicativeness, implications, limitations, and in terms of methodological procedural aspects of knowledge construction. It allows the children to be aware of the status of their own and others' conceptions and opens the way to conceptual change. This level also includes what is called "thinking about thinking", that is, the ability to reflect on the thinking process in itself as an object of cognition.

Stefano: Let's say that everyone in this class has confidence in his position and I say "I won't accept it, I can't change my idea, I need to see evidence, facts, first. Thirteen people may be wrong and only my conception may be right. When you vote for the head-students, they're elected by the majority. But in

this case, if you don't see the evidence, the majority doesn't win. Even when you say something and thirteen classmates say you're wrong, you can still win.

Piero: Changing an idea depends on personality. There are people who are satisfied with very little, a small evidence is enough for them. Instead, other people want to get into the usefulness of changing an idea, why they should change it, what the changing implies and all the consequences which the changed idea will lead to.

Laura: Let's say that I have argued very much about not throwing pieces of paper on the floor and then I do it. In that case I think that I don't care about it. That's my thinking. At that moment I don't reflect about what can happen, I think of something else and not about what I'm doing. I just do it, I don't reason about the consequences, maybe I'm in a hurry and I say to myself that a piece of paper can fly away. To reason that way suits me better at that moment.

4. Awareness of changes in one's own conceptual structures

The examples of sophisticated metacognitive reflections assigned to this fourth category are the children's explicitations of their experience in changing their conceptions to integrate new information with prior knowledge. They can think about the ways through which their previous ideas had been constructed (third level). In such a way they can reflect on why and how they had to change their mind.

Giovanni: Do you remember that I said burning wood polluted the air because it produced smoke? Now, I believe it doesn't pollute since wood's a natural thing, it comes from nature, its smoke isn't harmful to the air. Instead, in factories, if toxic substances are burned, their smoke pollutes.

Michela: I believed that we should prefer chemically treated vegetables because I knew that farmers had special good things to grow better crops. So those vegetables should be better than the others. Now, I believe that eating naturally grown fruit and vegetables would be better for our health.

Ylenia: The solution I gave at the beginning about constructing no more roads in the country ... About that, I've changed my mind because otherwise it wouldn't be possible to move about. I thought that, in the country, it was always possible to walk from one place to the other, but there are people who live far away and they cannot get there on foot. My classmates made me understand that it's absurd to think that it's always possible to walk everywhere.

It is remarkable that the four levels do not emerge in the sequence mentioned above. This can be seen in the excerpts of discussions reported below.

Metacognitive reflections within the dynamics of argumentation

After identifying the argument steps and the different levels at which the epistemic action concerning metacognition could be expressed in the children's discourse, we analyzed how the metacognitive reflections were explicited within the argumentative reasoning of classroom discussions.

The first extract is taken from the same whole-class discussion on manure as natural soil fertilizer, from which the text in Table 1 had already been taken.

Table 4. Is manure a fertilizer?

	Steps of Argument	*Levels of Metacognitive Reflections*
(463) *Teacher*: Jessica, do you think manure is a fertilizer?		
(464) *Jessica*: No, I know that it damages the soil.	*Claim*	Level 1: *Awareness of what one knows*
(465) *Federico:* Here we need a dictionary.	*Searching for a warrant*	Level 3: *Awareness of a methodological procedure in knowledge construction*
(466) *Paolo*: I think that you're wrong because if your father is manuring a field and you say to him "Don't manure it", he'll slap you!	*Ground (Implicit rebuttal)*	Level 2: *Awareness of why one knows something*
(467) *Teacher*: I'll give Jessica the dictionary and she'll look for the word "manure".		
(468) *Michela*: She's found the word. What does it say?	*(Conversational)*	
(469) *Jessica*: Straw below animals mixed with their dung. It is used as fertilizer.	*New Claim*	
(470) *Giordano*: Isn't manure a natural fertilizer, then?	*Implicit rebuttal appealing to the new claim*	Level 1: *Awareness of what one knows*
(471) *Jessica*: No!	*(Simple opposition)*	
(472) *Sheila*: But it explains it to you!	*Appealing to the warrant*	Level 3: *Awareness of the authoritative knowledge source*
(473) *Paolo*: Don't you believe it even if it's written there?	*Appealing to the warrant*	Level 3: *Awareness of the authoritative knowledge source*
(474) *Jessica*: No!	*(Simple opposition)*	
(475) *Federico*: I've just remembered that urea, the chemical fertilizer you've spoken about, contains a little dung. It's pigs' blood mixed with nitrogen.	*Rebuttal*	Level 1: *Awareness of what one knows*

(476) *Giordano*: Come on, Jessica! It says in there that manure's a fertilizer and you still don't believe it!	*Appealing to the warrant*	Level 3: *Awareness of the authoritative knowledge source*
(477) *Paolo*: What can we do then?	*(Conversational)*	
(478) *Sheila*: Jessica, what could we do to change your mind?	*(Conversational)*	
(479) *Jessica*: Nothing.	*(Simple Opposition)*	
(480) *Michela:* Nothing? Will you always have that doubt?	*Request for backing*	Level 3: *Awareness of methodological procedures in knowledge construction*
(481) *Jessica*: But I haven't got any doubt.	*(Simple Opposition)*	Level 1: *Awareness of what one knows*
(482) *Michela*: Why do you believe all the other words in the dictionary and not that word? Why? Why all the other words and not that one word? Tell my why.	*Appealing to an implicit backing*	Level 3: *Awareness of the extended value of the knowledge source*
(483) *Jessica:* They may have invented the meaning of that word.	*Rebuttal*	Level 2: *Awareness of why one knows something*
(484) *Sheila*: Good grief! (485) *Michela*: And if in all the other dictionaries and in every book it's written that manure is a fertilizer, won't you believe any of them?	*Appealing to an implicit backing*	Level 3: *Awareness of the extended value of the knowledge source*
(486) *Jessica*: No! (487) *Teacher*: Did everybody get together to agree on the meaning? (488) *Sheila*: In books there are no false things or invented information. There are true things.	*(Simple opposition)* *Backing*	Level 3: *Awareness of the legitimacy of the knowledge source*
(489) *Jessica*: That about manure, I see that it can't be true	*Rebuttal*	Level 2: *Awareness of why one knows something*
(490) *Giordano*: She won't change her mind even if you kill her!	*(No backing negotiation possible)*	

(491) *Federico*: Then, you'll eat only toxic food rather than change your mind?	*Referring to an implicit backing*	Level 3: *Awareness of when conceptual change is required*
(492) *Jessica*: I believe that chemical fertilizers are safer because they don't bring diseases. I know that manure is made of dung and I'm sure that dung is dirty and brings diseases.	*Warrant for the claim.*	Level 2: *Awareness of why one knows something*

In this extract, all the interlocutors, except Jessica, shared the common belief that manure is a natural fertilizer, the only one used by farmers in the past. Jessica's classmates tried to help her to change her belief by turning to a source of knowledge acknowledged by the whole class, that is the dictionary, very often used by them when looking for new meanings or clarifications. Her alternative belief was so entrenched and persistent and the classmates' conceptions was so implausible and alien to her conceptual ecology that she even argued that the dictionary was unreliable regarded the meaning of the word "manure". As can be seen, the sequence of discussion developed over continuously appealing and referring to warrants and backing to support the shared position and disconfirm Jessica's. Relying on their metacognitive awareness of a methodological procedure to support some information derived from their experience, Jessica's classmates adopted an argumentative strategy which took them to the higher steps of argument. At the same time, the request for warrants and backing induced by the very dynamics of argument stimulated sophisticated reflections on their knowledge, reaching higher levels of metacognition. The classmates' strategy seemed to have failed; indeed Jessica did not change her mind, but in the next session, she announced she had changed her mind about manure by talking with her grandfather who had given her some vegetables taken from a manured field. The child was actually so impressed by the classroom discussion that she looked for a more authoritative (in her opinion) source of information in order to find out whether her classmates were right. In such a way she abandoned her belief and restructured her knowledge.

The next extract comes from a small-group discussion focused on a topic of metacognitive nature; in fact it required reflecting on the process of knowledge restructuring to explain why, when, how the children changed their minds. They had pointed out how the majority could affect a person in keeping or rejecting her or his own belief.

Table 5. Changing an idea

	Steps of Argument	*Levels of Metacognitive Reflections*
(207) Teacher: To strengthen an idea, is the number of people supporting it important?		
(208) *Some*: Yes, it gives it strength.	*Claim*	Level 1: *Awareness of what one knows*
(209) *Marco*: I don't believe that number always means strength. Only if you have some doubts on what you know, the number of people is important. But if you're already sure that your idea is right, is true, you won't change it even if the majority doesn't have the same idea.	*Modal qualifier* *New claim*	Level 2: *Awareness of why one knows something*
(210) *Teacher*: Does number strengthen an idea?		
(211) *Marco*: Yes, somehow it does. You get confirmation from other people who have your same ideas.	*Claim*	Level 1 and 2: *Awareness of what one knows and why*
(212) *Teacher*: If many people share the same idea, does it make the idea more correct?		
(213) *Many*: No, no.	*(Simple Opposition)*	
(214) Marco: Evidence is necessary to confirm it.	*Appealing to grounds and warrants*	Level 3: *Awareness of knowledge construction procedures*
(215) *Ylenia*: If I have a wrong idea and another person has the same, if we compare each other, we don't reach a confirmation of that idea because we've both got the wrong idea.	*Possible rebuttal* (referring to 208)	Level 2: *Awareness of why one knows something*
(216) *Giovanni*: For example, sometimes when we're at "doposcuola"[2], we all have the same idea on how to solve a problem but we don't know if it's the right one, so we ask the nun for confirmation.	*Ground*	Level 2: *Awareness of why one knows*
(217) *Marco*: The nun is a confirmation because she knows about that more than us; she's older, more adult and she's got more right ideas.	*Warrant*	Level 3: *Awareness of an authoritative knowledge source*
(218) *Teacher*: Always?		
(219) *Marco*: Not always. If it's a matter of opinion, she can be wrong, but if it's a matter of sure things, that is, they are written somewhere, they were discovered, then she can't make mistakes. There's a book, or something like that, behind what she knows.	*Backing*	Level 3: *Awareness of the limited value of the knowledge source*

[2]The word "doposcuola" means an institution where children may study or enjoy recreation activities after school-hours.

(220) *Andrea*: As Galileo Galilei said, it's necessary to find a way to test theories to say that they're correct, true. It's necessary to experiment, to search for confirmations and then say. We've done the same thing with our classroom experiments on the biodegradability of various materials.	*Warrant* (referring to Marco 214)	Level 3: *Awareness of methodological procedures in knowledge construction*
(221) *Marco*: When we formulated our hypotheses, we didn't have a clear idea of what would happen. In fact, we had a lot of hypotheses. By the experiments some were proved true and some others false. When experiments disconfirm a hypothesis, there's something wrong that must be revised. Therefore we were forced to change some ideas.	*Ground* *Backing*	Level 4: *Awareness of mind changing*

This argumentative sequence shows a train of collective reasoning in which all the different constituents are present and the four levels of metacognitive reflections are expressed. What is particular interesting here is the content focused on by the discussion which forced the children to think within a metaconceptual dimension. Having recognized the fundamental role of evidence in confirming or disconfirming a conception, the speakers were aware that a warrant was needed to link grounds to claims in terms of significance and relevance. Then, they proceeded to state the foundation of the warrant by expliciting the backing. In this case, the warrant referred to an authoritative adult (a nun), whose authority was confirmed by means of the backing, the disciplinar knowledge underlying her competence. The use of the modal qualifier "not always" (Marco, 219) shows the awareness of the extent to which the nun's knowledge authority was acknowledged.

The two discussion sequences highlight how the children can reason at a very high level sharing the mental effort required by metacognitive thinking. It also shows that when the discourse-reasoning reaches the point at which warrants and backing have to be put forward in order to critically evaluate the expressed claims, the demand for metacognitive reflections increases. On the other side, the initial phase of an argument requires the awareness of the position stated in the claim. Its level is clearly lower than the one that a reasoned foundation of that claim will require.

The final excerpt is drawn from a discussion about recycling. In this argument there were two positions: (a) people who were in favor of the extreme importance of recycling and (b) people who did not. The children were divided by the teacher into two groups: the first had to find some relevant reasons and a valid train of argumentation in support of position (a), the second in support of position (b). The second group, on the basis of the answers given by the opponents to some strategic questions about why, when, and how they recycled and giving the different meaning to the terms "recycling" and "reusing", reversed the situation placing the blame for pollution on the "ecologist" part.

Table 6. Recycling and reusing

	Steps of Argument	*Levels of Metacognitive Reflections*
(21) *Stefano*: Does recycling pollute the environment? (22) *Sara*: I don't think so, it's the opposite!	*Claim*	Level 1: *Awareness of what one knows*
(23) *Marco*: We think you pollute because we know that to dissolve materials you need raw materials, machinery, you use electricity and so there's pollution.	*Rebuttal and Ground*	Level 2: *Awareness of why one knows something*
(24) *Stefano*: Got you! (25) *Luca*: In what way don't you pollute? (26) *Andrea*: Buying new materials instead of recycling, raw materials and energy are used. I think that more materials and energy are used that we don't waste by recycling.	*Rebuttal*	Level 2: *Awareness of why one knows something*
(27) *Sara*: Therefore, we have to say that both of them use energy, but I believe that recycling uses less than making the product from scratch each time and buying it completely new.	*Rebuttal*	Level 2: *Awareness of why one knows something*
(28) *Stefano*: But we don't always buy new items.	*Modal qualifier*	
(29) *Ylenia*: We reuse materials. (30) *Andrea*: You said that you don't reuse (31) *Group*: No, no, buddy. (32) *Marco*: We said that we don't recycle. Reuse and recycle are two different things.	*Claim*	Level 1: *Awareness of what one knows*
(33) *Andrea*: What do you do, then? (34) *Marco*: When we buy a product we look for a container made of recycled material and then we always reuse it. For example, we only buy detergent bottles once and then we refill them until they become useless. (35) *Andrea*: What's the container made of? (36) *Marco*: Plastic. (37) *Andrea*: When you throw it away, you pollute.	*Claim and Ground* *Rebuttal*	Level 1: *Awareness of what one knows*
(38) *Stefano*: No, it's made of recycled plastic.	*Claim*	
(39) *Andrea*: But then you recycle too!	*Rebuttal*	
(40) *Marco*: That's true. I admit it. It's right. Okay, once in a while we have to put something in the containers for recycling. But, only once in a while. Continuous recycling needs machines which use electricity.	*Modal qualifier* *Rebuttal*	Level 3: *Awareness of when mind changing is required*

(41) *Stefano*: We know that factories which recycle pollute through their chimneys.	*Rebuttal*	Level 1: *Awareness of what one knows*
(42) *Sara*: Yes, but listen. You pollute too. Listen. After reusing material, when you throw the stuff away, since you don't recycle, that stuff goes in the environment and so you pollute.	*Rebuttal*	Level 2: *Awareness of why one knows something*
(43) *Marco*: I think we're even. Both groups always pollute a little. But if you recycle once in a while and we reuse stuff instead of always throwing it away in the recycling container, we pollute less than you who always recycle as you said.	*Claim and Modal qualifier*	Level 2: *Awareness of why one knows something*
(44) *Andrea*: But then you have to admit that recycling is necessary. You have to change your mind.	*Rebuttal*	Level 3: *Awareness of when mind changing is required*
(45) *Marco*: Okay, we have to recycle sometimes but you must reuse material as much as possible. You have to change, too.	(Negotiation of a) *New claim*	Level 3: *Awareness of when mind changing is required*
46) *Paolo*: Maybe, yes, maybe. (47) *Andrea*: Yes, but I thought that people who don't recycle, never did it. If they do it sometimes, then that's different.	*Modal qualifier*	
(48) *Teacher*: What happens? (49) *Marco*: I say again that we are even in the sense that we sometimes pollute by throwing away and they pollute by continuously recycling. But, if we recycle once in a while, we use less energy. (50) *Andrea*: Come to think of it, that's a better solution. (51) *Sara*: I think that's true.	*Claim and Modal qualifier* *New claim* (referring to Marco 45)	Level 3: *Awareness of when mind changing is required*
(52) *Stefano*: Can you see that you're coming our way? (53) *Marco*: Sara begins to think that we're right. (54) *Sara*: I was thinking that, then, there is never an end. If you don't pollute in one way, you pollute in another.	*Backing*	Levels 3 and 4: *Awareness of knowledge construction procedures and of mind changing*
(55) *Andrea*: Both sides pollute (56) *Luca*: One less than the other. (57) *Sara*: Yes, but I wanted to say that you, thinking about waste in water ... Oh no. I had this thought earlier, but now it isn't right because if you said that sometimes you recycle ... then what I wanted to say isn't right any more. It isn't a valid objection.	*Modal qualifier* *Modal qualifier*	Level 3: *Awareness of the thinking process*
(58) *Teacher*: Can you reconcile the two initial positions? (59) *Giordano*: I understand that both sides pollute.	*Claim*	Level 1: *Awareness of what one knows*

(60) *Marco:* One thing is sure: if we don't pollute in one way, we pollute in the other to some extent. Actually, from your position we have learned that sometimes recycling is necessary and you have had to admit that it isn't convenient to continuously recycle because materials are reusable.	*Shared backing and negotiated claim*	Level 3 and 4: *Awareness of the limitations of previous knowledge and of conceptual change*
(61) *Andrea*: We are even. We have reached an agreement which is okay for both groups.		

In this argument the children reached an agreement which was half-way between the initial positions. What is interesting here is that the participants would not have reached an agreement by modifying their first position in some aspects, but they were cognitively and argumentatively compelled to construct together and accept a new shared solution. Supporting their claims, the children negotiated meanings and shared prior knowledge about the problems of recycling and pollution. The rebuttals followed one another swiftly and forced the interlocutors to take into account the limitations and contradictions of their claims and to restructure their position, giving the argument an unexpected turn. Clearly, that involved a corresponding conceptual change with metacognitive effort.

Discussion

The discourse-reasoning produced by the children engaged in discussion about knowledge objects was analyzed in different ways. First of all, the collected data showed the social nature of the reasoning required when the learners collectively negotiate and share meanings to construct new knowledge. Reasoning can develop through steps of co-construction and steps of critical opposition. In the first case, a shared idea passes from mind to mind gathering strength, articulation, and depth. In the case of critical opposition, the limitations and contradictions of a position submitted to a rational examination arise. In both ways, the children were facilitated in increasing, tuning or restructuring their knowledge with respect to their conceptual ecology.

The constituent elements of argument proposed by Toulmin (1958) were useful to examine the classroom discussions as sets of collective trains of reasoning aimed at expliciting, comparing, and evaluating points of views.

The analysis of epistemic actions proposed by Pontecorvo (1987) allowed us to see the different cognitive procedures carried out by the children engaged in meaningful learning through discussions.

The central aspect of this study was to relate argumentative dynamics to metacognitive reflection in constructing knowledge. The data coming from the analysis confirmed the hypothesis that the deepest steps of argument were characterized by the highest levels of metacognitive thinking. The three excerpts of discussions highlight how the upward argumentative dynamics appealed to sophisticated levels of metaconceptual reflection which in turn allows the argumentation to progressively develop and deepen.

Critically arguing together on questions which imply the explicitation of a basis supporting one's own claims strengthens the metacognitive dimension of thinking. To be aware of what one does or does not know is a basic condition for the development of a dialogic argument. In a reasoned argument, this kind of awareness is expressed by claims. Through the explicitation of the reasoning behind a conception, often a ground is introduced to support the claims put forward. When the collective reasoning reaches the point at which warrants and backing are requested to guarantee the trustworthiness of the argument, higher levels of metacognitive reflections are involved. Searching for an acknowledged basis of reference to support their positions, students think about the genesis, maintenance, and reliability of their beliefs and theories. In such a way they can experience the need to change their mind being aware and responsible of it. Therefore, the argumentative structure of a collective reasoning induces reflection on what, why, how, when one knows.

It must be said that not every classroom discussion developed at a high level of argument. This was due to different reasons at the procedural level: the question space was not clearly identified; there was a marked deviation from the central subject; there was not enough collective consensus to validate the examined question. In addition, at the social level some interpersonal relation problems, among them role conflicts, emerged. Some children tended to not verbalize their points of view or did so with some difficulty because of their lower linguistic-conversational competence and their classroom status. On the other hand, if a student does not express her or his ideas during a discussion she or he can follow the thread of the reasoning and take advantage of it at individual level. Moreover, not all thinking processes and therefore not all metacognitive operations are statable.

The frameworks and tools used for the argumentative and epistemic analysis allowed to grasp the structure of a collective reasoning in terms of its inner logic and cognitive procedures but not the interactive social nature of the progressive development of a negotiation aimed at reaching a shared reasoned view. Therefore, a new framework taking into account also the qualitative evaluation of that development would be particularly appropriate and useful.

Two directions could be open to future research: on the one side the analysis of the specific roles played by the interlocutors in relation to the argumentative dynamics and the metacognitive dimension of reasoning. On the other, the analysis of the effects produced by social cognitive interaction on individual students in terms of conceptual change and internalization of argumentative procedures.

Educational implications

This study shows that by assigning a relevant role to classroom discussions, innovative learning environments are established. In a social constructivist classroom with an emphasis on discourse, the teacher does not use language to display disciplinar information giving finite answers but, rather, as a communicative tool for students to construct and reconstruct shared knowledge. In a social

constructivist learning community, students should feel free to express their beliefs and to compare them with the other members' beliefs in order to socially construct their understanding. In such learning setting students can not only hear a problem but rather talk about a problem, being involved in it. Meaningful learning is more likely to occur when there is not an external amount of information to be acquired but a body of knowledge to be socially structured and restructured in relevant situations. In this way knowledge is viewed as tentative and continuously evolving. Students, as members of the learning community, play a crucial role in shaping the knowledge learned in the classroom.

Teachers can exploit classroom discussions to encourage both the learning of new knowledge through the negotiation of meanings and the acquisition of procedures to construct knowledge. Arguments should allow students to transform their own personal beliefs in reasoned views even beyond the specific dialogic situations. That is, students should gradually be able to think individually, addressing the "generalized other" (Mead, 1934) or the "universal audience" (Perelman, 1958). Searching for valid reasons to found their ideas on, students foster the metacognitive dimension of thinking, recognized crucial for learning and understanding. They can express their own conceptions and be aware of them, and this is extremely relevant for conceptual change learning. This is also important to teachers in order to realize an appropriate and productive educational intervention anchored on students' previous mental representations to be compared with formal disciplinar knowledge. Teachers should consider that in becoming socialized to the complex scientific culture of our societies, students need to be engaged in sharing meanings and ways of reasoning and arguing. Crucial to this, is the organization of learning environments as communities of discourse that create the social context of group discussion providing social support for the efforts of their members. In this way new levels of competence can be promoted in learners operating within their zone of proximal development in a kind of cognitive apprenticeship.

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